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REPORT OF SERIOUS INCIDENT

BY

CONTRACTOR INVESTIGATING COMMITTEE

K25RC

NOT TO BE LOANED FROM  
PLANT RECORDS K-1034

KS-222

Description of Damaged Property: A Standard One Ton Chlorine Type  
Feed Cylinder, Number D-21157  
(Carbide and Carbon Chemicals  
Company Number 203254)

Extent of Damage to Government Property: Fracture of cylinder end  
plate. Total estimated  
damage, \$225.00.

Time of Incident: August 5, 1951, 10:25 P.M.

Location of Incident: Carbide and Carbon Chemicals Company, K-25  
Plant, Oak Ridge, Tennessee, K-1131 Building,  
Ground Floor.

Description of Incident:

During electrical heating of the process gas in a one ton chlorine  
type cylinder in preparation for its transfer to the cascade, internal  
pressure deformed and cracked one end plate of the cylinder and resulted  
in the release of approximately 200 lbs. of process gas into the building.

Findings

1. Dispensary examination of the 10 employees involved revealed  
minor chemical burns on the legs of 4 employees, and no apparent respira-  
tory injuries from possible inhalation.

2. The one ton chlorine type cylinders are manufactured according  
to ICC specification 106A500 for shipping cylinders and, at K-25, are  
normally cleaned and pressure tested at 550 psig before use. The cyl-  
inder volume as designed should be 25.6 cu. ft.; however, the cylinder  
volumes of 140 such cylinders were found to vary between 26.1 and 27.0  
cu. ft.

3. In June, 1951, the affected cylinder was tested at 100 psig  
air pressure and at 550 psig water pressure without leak or permanent  
deformation. It was later filled with 4,734 lbs. of process gas at the  
Feed Plant, stored for approximately one month, and returned to the  
Feed Plant for transfer to the cascade.

4. The transfer unit consists of an electrically heated furnace  
in which the cylinder is heated to vaporize the process gas and thus

Carbide and Carbon Chemicals Corporation Operating  
Contractor for the U.S. Atomic Energy Commission.

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Classification changed to:

UNCLASSIFIED

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transfer it to one cascade. The air surrounding the cylinder is circulated with a fan to improve heat transfer from the air to the cylinder. Accident prevention features considered to be essential to safe operation of the unit and included in the original design are as follows:

- a. A pressure controller actuated through a pressure transmitter by the gas pressure in the line leading from the cylinder and connected to cut off the furnace heaters at a set line pressure.
- b. A Mercoid temperature switch in the air stream connected to cut off the heaters when the circulating air reaches a set temperature. The maximum temperature set is 380°F.
- c. A Chromalox temperature switch in contact with the process gas cylinder shell and connected to visual and audible alarms, one in the control room and one locally placed, set to operate when the shell reaches a given temperature.
- d. An air flow switch in the circulating air stream connected to cut off the heat in the event of circulation failure.

The Mercoid and Chromalox temperature switches are considered necessary for safe operation inasmuch as the pressure controller could be, in effect, removed from the system by either a plugged line or failure of an operator to open the cylinder valve before heating. It now appears that the Chromalox switch should have been connected as a heater cut off to act as an override control for the Mercoid air stream temperature switch.

5. At the time of the incident, the condition of the above protective devices was as follows:

- a. The pressure controller as described in 4a above was set to actuate at 70 psig.
- b. In an attempt to accomplish liquefaction of the process material in a reasonable time, the Mercoid was set at its maximum, or 380°F. On the reasonable assumption that the temperature of the cylinder would not reach the circulating air temperature, this set was not considered dangerous.
- c. The Chromalox switch, because of apparent unsatisfactory operation, had been replaced by a thermocouple connected to a spare point on a 300°F maximum speed range Speedomax recorder.
- d. The air flow switch did not function satisfactorily due to surging in the air stream and had been removed from service.

6. Liquefaction of the process gas before opening the feed rate control valve is considered essential to satisfactory operation of the system.

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Although the initial heating period usually required to liquefy the condensed material and raise the vapor pressure to 70 psig is only about 8 hours, the pressure controller would normally prevent overheating of the cylinder even if the unit were left unattended for much longer periods. The normal temperature of the process gas during transfer to the cascade is approximately 200°F.

7. At approximately 1:30 A.M., August 5th, the cylinder in question was placed in the furnace preparatory to transfer of the process gas to the cascade. Before heating, the pressure indicator showed the pressure in the cylinder to be 10 psig, thus indicating the presence of contaminants of which hydrogen fluoride was probably the principal constituent. During heating to liquefy the process gas, the pressure recorder chart indicated that the cylinder pressure rose to 42 psig in 2 hours and then remained constant until the time of the rupture, 19 hours later. The circulating air temperature rose to the top of the recorder range (300°F.) in 3 hours and then remained off scale.

8. After the rupture, a leak was discovered in the line between the pressure transmitter and the pressure recorder controller, and the line from the cylinder to the pressure transmitter was found plugged. A leak of the type found would cause the recorder controller to indicate apparent pressures lower than the actual pressure, thereby preventing proper control of the furnace heaters. Heating, thus improperly controlled, would increase the cylinder pressure which, in turn, could probably cause the process gas to freeze out and plug the line to the pressure transmitter. Under these conditions, the supply of heat to the cylinder would continue uninterrupted until manually controlled.

9. The ruptured cylinder, the volume of which was 26.7 cu. ft., would have been completely filled with the 4,734 lbs. of liquid process gas at 360°F. Heating of the liquid above this value would thus result in the exertion of a very large hydrostatic pressure against the cylinder walls. However, it should also be noted that the vapor pressures of process gas and hydrogen fluoride at 360°F. are 330 and 480 psia, respectively.

### Conclusions

The committee found that the primary cause of the cylinder rupture was the build up of internal pressure resulting from the failure and inadequacy of operational control equipment.

### Recommendations

#### 1. Action Taken To Prevent Recurrence

- a. The maximum capacity of the one-ton chlorine type cylinders is now regarded as 5000 pounds and the operating limit during

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filling is set low enough so that the 5000 pound maximum will include the maximum expected filling error.

- b. Until such time as engineering studies can be completed, the operation of the steam and electric units throughout the plant will be continued for heating cylinders which contain less than 5000 pounds of process gas with the following limitations:
- (1) Audible warning devices will be installed on the steam heated units to alarm when the steam temperature exceeds 250°F. These devices will provide additional protection against failure of the steam reducing and relief valves.
  - (2) The following precautions for electrically heated units will be taken:
    - (a) The Mercoid temperature switch will be set to hold the circulating air temperature below 250°F. and an over-ride control will be installed as additional protection and will be set to limit the skin temperature of the cylinders to 250°F.
    - (b) Insofar as practical, the system will be valved so that an open line exists between the cylinder and the receiving system. When it is necessary to liquefy the process gas before valving into the receiving system, the liquefaction time will be held to 8 hours.
    - (c) The range of the circulating air temperature recorder in the feed bath has been extended to include all normal operating temperatures.
    - (d) The present method of controlling heat by cutting off the heater when the cylinder pressure reaches 70 psig will be retained in the Feed Plant as operational control.
- c. Cylinders now filled in excess of 5000 pounds will be treated as follows:
- (1) Cylinders filled in excess of 5100 pounds will be tagged and held until engineering studies are completed, then processed subject to the findings from the study.
  - (2) Since it is not feasible to hold cylinders which are now filled with 5000 to 5100 pounds, these units will be processed in a steam or electric unit in the same manner as those which are filled with less than 5000 pounds and the operating temperature will be chosen to compensate for the expansion of the additional 100 pounds of material.

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2. Remaining Action To Be Taken To Correct Condition

Engineering evaluation studies are now being conducted to determine the safest and most efficient methods of heating cylinders which contain process material.

INVESTIGATING COMMITTEE

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K. P. Moseley:mmp

October 18, 1951

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